STUDY ON ELEMENTAL CONCENTRATION IN AIR PARTICULATE MATTER BY ICP-MS[1)]

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Abstract This study conducted air particulate matter sampling to measure the total suspended particulate (TSP), PM_{10} (particles< 10 μmm in aerodynamic diameter) and $PM_{2.5}$ (particles< 2.5 μmm in aerodynamic diameter) mass concentration at Tongan district in Xiamen. One hundred and nineteen samples were obtained to measure the mass concentrations of TSP, PM_{10} and $PM_{2.5}$ during 15 April to 6 June 2002. According to these results, the TSP, PM_{10} and $PM_{2.5}$ mass concentrations varied from 53 $\mu g \cdot m^{-3}$ (from 26 to 105 $\mu g \cdot m^{-3}$), 48 $\mu g \cdot m^{-3}$ (from 23 to 74 $\mu g \cdot m^{-3}$) and 41 $\mu g \cdot m^{-3}$ (from 18 to 62 $\mu g \cdot m^{-3}$), respectively. 18 elemental concentrations were determined by ICP-MS, most elemental profiles were lower than previous studies. However, high levels of Pb and Zn indicate some pollutants existed in air particulate matter.

Keywords TSP, PM_{10}, $PM_{2.5}$, ICP-MS, Xiamen.

1 Introduction

Airborne particulate matter is one of the important markers of air quality and is an important health concern in urban areas, especially with respect to a number of chronic respiratory diseases. Medical data suggests that it is this fraction of particulate matter that becomes deeply imbedded in human lung tissue and causes respiratory problems and exacerbates other cardiovascular diseases. In addition to the negative health effects, airborne particulate matter reduces visibility and speeds the deterioration of buildings[1,2]. The primary man-made sources of $PM_{2.5}$ and PM_{10} include fugitive dust from motor vehicles, combustion of solid fuels, agricultural activities, and construction activities. Volcanic emissions, wind blown dust, marine aerosols and fly ash from forest fires are some of the more important natural sources of $PM_{2.5}$ and PM_{10}[3,4]. Particles can also be formed in the atmosphere by the condensation or the transformation of emitted gases such as sulphur dioxide and volatile organic compounds.

Monitoring of air quality data is used to verify compliance with local and national air quality standards, to support development of regulations designed to reduce air pollution, to assess the electiveness of existing air pollution control strategies and to provide data on special research projects.

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In cities such as Xiamen, due to the lack of adequate emission inventories, measurements of aerosol constituents seem to be a practical way to provide information about pollution sources using receptor modelling techniques.

The purpose of the study was to collect baseline $PM_{2.5}$, PM_{10} and TSP data from a selected area of study, compare the levels found with previous standards, analyze the data in terms of temporal and spatial elects and perform correlations between various parameters.

2 Experimental

2.1 Sampler collection

Figure 1 shows the map of the sampling location. The sampling site (Xiaoping) is situated at the Tongan district of the northwest of Xiamen, which is about 60km away from the city. This location represents the low- density residential and commercial area in Xiamen. This sampling height is 600 meters height above sea level.

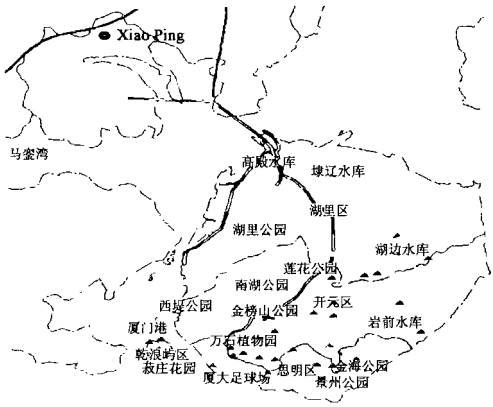

Fig. 1 The map of the sampling location

2.2 Sampling methods

Air filter samples were collected for 24 hours, at the recorded sampling rate, from 10:00 am to 10:00 am on the following day. The sampling period was carried out from 15 April 2002 to 6 June 2002. Three types of samplers were located at the same site: TSP, PM_{10} and $PM_{2.5}$ sampler using 2.0 and 1.0μm Teflon membrane filters. Also, the filter blanks of the three filters were collected. Note that the field blank filter was the brand new filter, with no air drawn through, placed in another sampling cassette at the same sampling location next to the sampler.

The incoming flow rate was set at 16.7 $L \cdot min^{-1}$ and the diverted flow was controlled at a rate of 13.6 $L \cdot min^{-1}$, separating by a flow splitter into other 8 lines heading to 8 cartridges in the ACCU system. The automatic cartridge collection unit system was equipped with the collection devices for ICP-MS analysis. In the cone-shaped collection device, the aerosols were dispersed homogeneously on the filter surfaced. Also, an additional cyclone inlet (pre-classifier) of 2.5 μmm cut-off was placed underneath of the PM_{10} inlet for $PM_{2.5}$ collection. Note that two identical sampling de-

vices were installed with different filters. (The two 47 mm TSP filters were: (1) 1.0 μm PTFE membrane from Advantec Micro Filtration System, MFS; and (2) 2.0 μm Teflon membrane from Whatman Inc., USA.)

2.3 Filter handling and pre-treatment

All loaded filters were stored in sealed tight zip-loc plastic bugs after sampling. Those filters were put in a plastic Petri dish, and the Petri dish was sealed with plastic tapes and placed in a desiccator containing silica gel. The Petri dish was stored in a fridge at 4℃ prior to analysis. During transportation, the sample filters were placed in an air tight plastic box, which was desiccated with silica gel. All filters were handled with a pair of plastic tweezers, which were cleaned with methanol thoroughly beforehand. The sample filters were then placed into the sample changer with the loaded surface faced down.

2.4 Gravimetric measurement

The sample filters were weighted gravimetrically until constant weights were obtained in a humidity controlled chamber, using a micro-balance with a sensitivity of ±0.1mg of the model Shimadzu. The weighed filters were placed back in a desiccator for future analysis.

2.5 ICP-MS measurement

The half of the loaded filters was digested on a hot plate with a mixture of concentrated HNO_3 and $HClO_4$, followed by evaporating to near-dry after complete digestion. The residue was diluted into 50ml volumetric flask. Linear regression was adopted to relate the emission intensity and the mass concentration of the water-soluble ions. 18 water-soluble cations were analyzed within a reasonable working linear range (0 to 200 $\mu g \cdot l^{-1}$), including Al, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Na, Ni, Pb, Sr, and Zn.

3 Results and discussion

3.1 Comparison of the TSP 1.0 and TSP 2.0 filters

Two blank filters of 47mm diameter and of pore sizes of 1.0 and 2.0 were examined. The results show the element concentrations of all trace metal impurities from 2.0 μm Teflon filter were lower than that of 1.0 μm Teflon filter except for Al, Mg, Pb.

3.2 Mass concentrations

In this work, the average mass concentrations of TSP, PM_{10} and $PM_{2.5}$ are 53 $\mu g \cdot m^{-3}$ (from 26 to 105 $\mu g \cdot m^{-3}$), 48 $\mu g \cdot m^{-3}$ (from 23 to 74 $\mu g \cdot m^{-3}$) and 41 $\mu g \cdot m^{-3}$ (from 18 to 62 $\mu g \cdot m^{-3}$), respectively. The mass concentrations of TSP, PM_{10} and $PM_{2.5}$ were almost equal to that of the same period reported by XMEMS in 2001.

3.3 Elemental concentration profile

The 18 elements were determined on a Teflon filter by ICP-MS. Those water-soluble cations include Al, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Na, Ni, Pb, Sr, and Zn.

Figure 2 presents the average individual elemental abundances in TSP, PM_{10} and $PM_{2.5}$. The numerical descriptive data are tabulated in Table 1. The descending order of individual elemental

abundances of the TSP, PM_{10} and $PM_{2.5}$ are: Zn > Na > Fe > Al~ Ca > Pb > K > Mg > B > Cr > Cu~ Mn~ Ba~ Cd > Sr~ Ni~ Li~ Co.

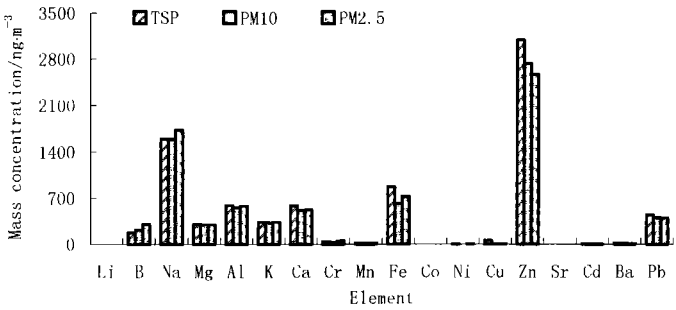

Fig 2 Average individual elemental abundances in TSP, PM_{10} and $PM_{2.5}$

Table 1 Average elemental concentration ($ng \cdot m^{-3}$) of TSP, PM_{10} and $PM_{2.5}$

Elements	TSP		PM_{10}		$PM_{2.5}$	
	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max
Al	591.06	0—1676	561.54	0—2106	579.18	0—1707
B	177.59	0—1495	219.37	0—22520	304.21	0—1624
Ba	17.84	0—67.7	15.94	0—64	15.39	0—57.7
Ca	590.88	0—2070	516.30	0—2110	528.24	0—2366
Cd	7.50	0—65.9	6.17	0—65	5.31	0—48.8
Co	—	—	—	—	—	—
Cr	45.34	0—797	36.14	0—263	54.32	0—440
Cu	57.56	0—1761	8.91	0—40.9	7.49	0—31.8
Fe	869.03	0—8109	619.67	0—2454	729.03	0—3432
K	339.17	0—928	327.94	0—1183	341.73	0—790
Li	1.06	0—4.81	1.1	0—8.88	1.27	0—5.7
Mg	304.07	0—4111	300.68	0—1663	302.61	0—1039
Mn	21.22	0—76.7	19.18	0—80.7	17.89	0—65
Na	1596.07	0—5299	1594.76	0—8026	1728.96	0—5718
Ni	2.83	0—24.7	2.00	0—11.3	2.81	0—16
Pb	449.62	11.6—1766	408.54	6.7—1742	403.60	14.9—1528
Sr	1.76	0—11.8	1.57	0—11	1.24	0—11.4
Zn	3093.12	53.1—13131	2738.37	34.3—11764	2570.39	34.9—11795

The TSP/PM_{10} or TSP/$PM_{2.5}$ ratio of individual elements indicates the association of the elements with different particle fractions. As shown in Figure 2, the Ca, Cu, Fe, Pb, Zn are more abundant in TSP. Because soluble ions such as Na and Mg originate from a marine source, similar concentrations of Na and Mg in TSP, PM_{10} and $PM_{2.5}$ are observed. The crustal elements (Al, Ca and K) and marine source ions (Mg) compared with Gao's are lower. But the abundance of Ca/Ba in TSP, PM_{10}, $PM_{2.5}$ and Gao's[5] is 33.12, 32.39, 34.32 and 32.18, respectively. Moreover,

the levels of other anthropogenic elements, such as Cr, Co, Cd, Ni and Cu found in this study are not high, but high levels of Pb and Zn may be principal pollutants in Xiamen air.

4 Conclusion

The practical methodology for the determination of elemental concentrations on air filters from sampling to measurement has been developed. Teflon membrane filter permits itself for the simplest mathematical quantification model. Furthermore, the 2.0μmm Teflon membrane filter showed low filter blank levels and less variable elemental concentration results, so that the results obtained from the 2.0μmm Teflon membrane filter were adopted throughout.

The ICP-MS calibrations are established using the Teflon filters provided by XMEMS. The precision and accuracy for most analyzed elements were good, indicating that the current method was suitable for determining these elements concentration in Xiamen air particulate matter. For better precision, the ICP-MS instrument should be entirely used for the aerosol analysis after the calibration programs have been established.

The elemental compositions of TSP, PM_{10} and $PM_{2.5}$ have been examined. Most elemental profiles were lower than previous studies reported by Gao. This may be due to the fact that the sampling location is rather high and far from industrial activities. However, the high levels of Pb and Zn indicate some pollutants existed in Xiamen air particulate matter. Furthermore, the number of samples was not sufficient to generate conclusive remarks.

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电感耦合等离子体-质谱法研究大气颗粒物中元素浓度

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